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Kessler et al.

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[54] **VAPOR DEPOSITION ON ELECTROSTATICALLY TENSIONED FOIL**

[75] Inventors: **Hartmut Kessler; Hubert Kraus,** both of Regensburg, Germany

[73] Assignee: **Siemens Aktiengesellschaft,** Berlin & Munich, Germany

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[51] **Int. Cl.**^{2}.. **C23C 13/08**

[58] **Field of Search**..................... 118/8, 7, 48–49.1; 324/54; 226/94, 195

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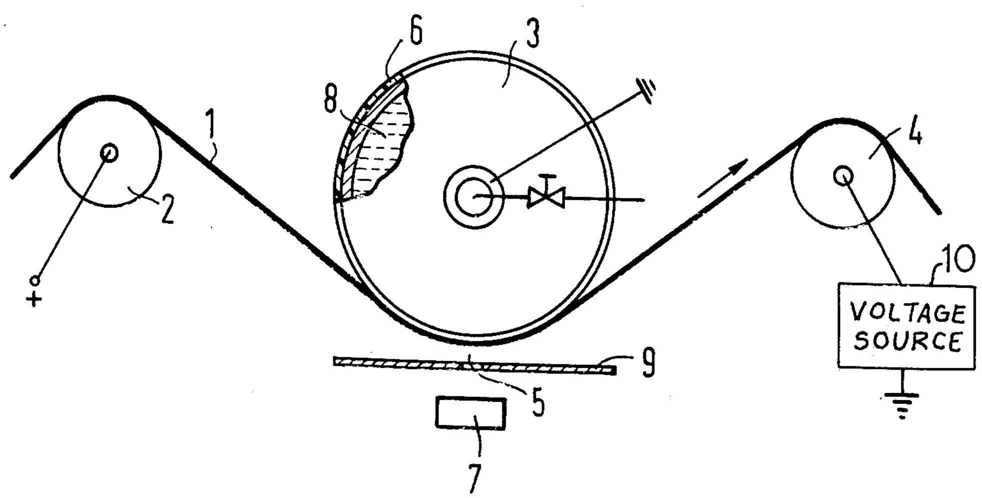
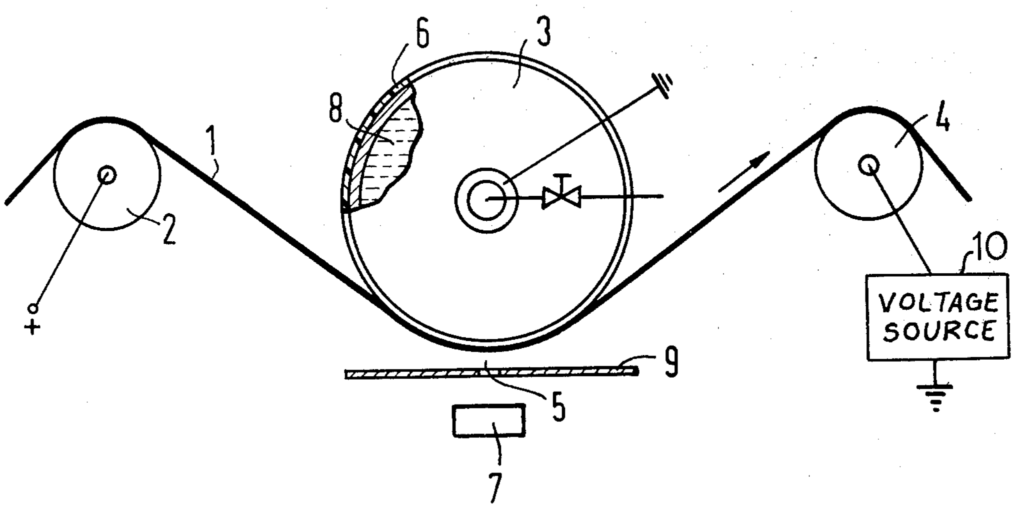
Primary Examiner—Morris Kaplan
Attorney, Agent, or Firm—Hill, Gross, Simpson, Van Santen, Steadman, Chiara & Simpson

[57] **ABSTRACT**

A method of vapor depositing metal on plastic foil which maintains the foil smooth so as to prevent creases and wherein the foil is passed over a cooling drum which is covered with an insulating layer and wherein an electrostatic charge is maintained between the foil and the cooling drum so as to cause attraction between the foil and the cooling drum thus assuring good contact and smooth foil arrangement on the drum as the foil is metalized. Simultaneous testing of weak spots in the foil are tested. The insulating layer on the drum is broken into small areas and the product of its resistance and its thickness is selected so that it does not exceed one-fifth of the product of the resistance and thickness of the foil.

3 Claims, 1 Drawing Figure




6
3
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1
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+
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VOLTAGE
SOURCE
9
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VAPOR DEPOSITION ON ELECTROSTATICALLY TENSIONED FOIL

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates in general to a method for depositing metal on plastic foils in a vacuum chamber which can be used for the regeneration of capacitor foils.

2. Description of the Prior Art

It has been known in the past to deposit metal vapors on plastic foil, but creases and folding of the foil have occurred as they pass through the metalizing region.

SUMMARY OF THE INVENTION

The present invention provides a cooling drum filled with a cooling substance and which has an outer metal surface over which is provided a layer of insulation material which engages one side of the plastic foil upon which the metalized layer is formed. An electric field is applied between the metalized layer and the cooling drum so as to attract the plastic film and hold it smooth and unwrinkled under the drum as vapor deposit of metal occurs on the opposite surface of the plastic foil. The electric field will also cause breakdowns at holes or weak points of the foil which are clearly distinguishable from common burnouts which occur in air under pressure in that a much larger area of the metal coating is effected. The inventors have discovered that by incorporating a special barrier resistance in the current supply line that the area of the burnout regions can be controlled so that they do not cover as large an area. Due to the high number of breakdowns, the voltage will decrease behind a normal barrier resistance because of the current required to charge the insulating areas where breakdown has previsouly occurred.

The present invention allows the maintaining of the optimum voltage between the coating and the cooling drum for the vapor deposition of metal in that the present invention provides for the maintenance of the optimum voltage necessary for preventing heat creases and wrinkles in the plastic film during the vapor deposition even though burnout paths cover a large area.

According to the invention, the problem is solved by the provision of an insulating layer over the cooling drum as a barrier resistance which has an electrical resistance and a thickness so as to assure that a clean, however, limited area of burnout of the coating takes place in the area of pores or weak points of the plastic foil. A clean burnout in this invention means that an electrically conductive connection to a metal layer does not exist or remain through the pores of the plastic foil.

The insulating layer on the cooling drum serves as a barrier resistance and has a sufficient resistance that means it has a small enough resistance per unit area relative to the vapor deposited foil to allow a large portion of the applied voltage to be applied to the dielectric foil to assure that the foil is attracted and held smooth on the cooling drum. A high degree of efficiency is achieved when the insulating layer on the drum is selected so that the product of the specific resistance and its thickness does not exceed a value equal to one-fifth of the product of the specific resistance and the thickness of the plastic foil.

An advantageous embodiment of the invention lies in the fact that plastic foil is attracted to a cooling drum by electrostatic forces in the area where vapor deposition of metal occurs and wherein an insulating layer in the form of an insulating foil passes with the plastic foil across the cooling drum. Thus, the advantages achieved that over and over again different areas of the insulating layer come in contact with the drum and with the plastic foil and breakdown channels do not form through the insulating layer. The insulating layer is strong enough if its resistance is chosen large enough such that the voltage necessary for the creation of the electrostatic forces to attract the foil to the drum does not cause a breakdown through the insulating layer even in the weak points of the foil. The insulating layer does not necessarily have to have a voltage resistance which by itself prevents the breakdown of the voltage through the insulating layer but it need only have a resistance to the applied voltage which is necessary for the prevention of breakdowns at the weak points of the foil which has been vaporized.

When breakdowns and burnouts occur, the energy is limited so that burning out takes place, but excessively large destruction of the coating in the area of the breakdowns does not occur. However, the electrostatic field is maintained at its normal value so that attraction between the foil and the drum does not decrease. On the other hand after starting the evaporation the entire electrostatic force should be available within a few seconds.

These two conditions allow a time constant to be selected which results from the product from the absolute dielectric constant and a specific resistance of the insulating layer. It has been discovered that it is desirable to choose a time constant between 10 microseconds and 1 second. Thus, the upper limit is set by the requirement that after the vapor deposition has commenced, the electrostatic field forces should become fully effective without an unusual delay which means should occur after a few seconds. The lower limit is set physically in that during a possible breakdown which occurs the charge from the adjacent areas has to be strongly retarded and delayed so that only a very small fraction of the energy in the entire capacitor between the coating and the surface will be supplied during the short duration of the breakdown which occurs during a time of approximately 1 microsecond in the breakdown spark.

In addition, it is advantageous to provide a barrier resistance in the current feed line such that during short duration of the breakdown spark, energy is not supplied from the voltage source. Since, according to the present invention, the number of breakdowns and the total energy dissipated during a breakdown is maintained, a high resistance value, as for example, 50,000 ohms can be chosen for the barrier resistance.

The insulating layer can be formed on the cooling drum as an endless belt which engages the drum at the point and areas where the plastic foil contacts the cooling drum.

Another arrangement may be made wherein the cooling drum is covered with an insulating layer which might, for example, be a thick cellulose propionate layer about 10 micrometers in thickness. The insulating layer can be improved so as to taper the amount of energy discharged in the case of breakdowns if the cylindrical wall of the cooling drum is composed of a multitude of small cells which are insulated from each other and which are connected to each other electrically by a voltage source via barrier resistances and wherein the barrier resistances are selected such that the time constant for charging them relative to the vapor deposited coating is between 10 microseconds and 1 second.

In such an arrangement, the electrostatic adhesion between the foil and the drum can be reversed prior to removing the foil by discharging the area of the cooling cylinder wall adjacent the point where the foil is to leave the cooling drum. The surface of the cylinder wall of the cooling drum can be preferably designed in rasterlike form or in stripes.

Other objects, features and advantages of the invention will be readily apparent from the following description of certain preferred embodiments thereof, taken in conjunction with the accompanying drawing, although variations and modifications may be effected without departing from the spirit and scope of the novel concepts of the disclosure, and in which:

BRIEF DESCRIPTION OF THE DRAWING

The FIGURE illustrates the novel method of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The FIGURE illustrates the plastic foil **1** which passes over a first guide roller **2** and then over a cooling drum **3** and over a second guide roller **4**. The cooling drum **3** may be filled with a cooling liquid **8** as shown in cutaway. The outer wall surface of the cooling drum **3** may be coated and covered with an insulating layer **6** which has a resistance per unit area which is small relative to the resistance per unit area of the plastic foil **1**.

A voltage source **10** has one side connected to ground and has its positive terminal connected to the guide roller **4** and the metalized layer of the foil engages the electrically conducting roller **4** so as to apply a positive charge to the metalized side of the foil **1**. The cooling drum **3** has an inner conducting portion which is grounded so that electrostatic attraction exists between the foil and the drum so as to hold the foil smoothly onto the drum **3**.

In the area where the foil is held smoothly to the cooling drum **3**, metal coating is applied from an evaporator **7** which applies metal vapor through the opening **5** in the shutter **9** onto the foil.

The surface of the cooling drum **3** may be formed by several mutually insulated pieces or stripes which are grounded only near the opening **5**.

In operation, the rollers **2** and **4** are driven with the roller **4** being connected to the positive terminal of the voltage source **10**. The roller **2** may also be attached to the positive terminal of the voltage source **10** so as to apply a positive potential to the foil **1** before it reaches the drum **3**. The cooling drum is grounded and thus, the foil is attracted and held on the surface of the cooling drum in the metalizing region and a metal layer is deposited from the foil from the evaporator **7** through the opening **5** in the shutter **9**. The insulating layer **6** is selected such that the produce of its thickness and its resistance per unit area is approximately one-fifth of the product of the resistance per unit area and the thickness of the plastic foil **1**.

It is seen that this invention provides an improved method for uniformly and smoothly appling a metal layer to an insulating foil; and although it has been described with respect to preferred embodiments, it is not to be so limited as changes and modifications may be made which are within the full intended scope as defined by the appended claims.

We claim as our invention:

1. Apparatus for vapor deposition of a metal layer to a plastic foil comprising a metallic cooling drum rotatably supported, an insulating layer covering the cylindrical surface of said cooling drum, means moving said plastic foil with one surface entrained about said insulating layer on said cooling drum, means for applying a metallized layer to the opposed surface of said plastic foil at the area of entrainment and voltage means for applying an electrostatic field between said cooling drum and said plastic foil including an electrically conducting roller engageable with the metallized side of the plastic foil.

2. Apparatus according to claim **1**, wherein the product of the specific resistance and thickness of said insulating layer on said cooling drum is less than one-fifth of the product of the specific resistance and thickness of said plastic foil.

3. Apparatus according to claim **1** wherein the surface of said cooling drum is formed with strips so that said insulating layer is divided into small areas.

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